Lower East Coast Aquifer Storage and Recovery. DRAFT (9/11/98)

Description of Simulations

A sensitivity analysis of the proposed Aquifer Storage and Recovery (ASR) systems in the Lower East Coast (LEC) of Florida was completed using the South Florida Water Management Model (SFWMM). Outputs from three model simulations were compared.

The first or base model run corresponds to the C&SF Comprehensive Review Study (Restudy) Alternative D13R which was posted on the Hydrologic Performance Measure Web page on June 19, 1998. This alternative proposes four major locations for ASR wells in the vicinity of **W**est **P**alm **B**each **Cat**chment Area, **C**-**51** canal, the proposed **C**entral **P**alm **B**each County agricultural reserve **res**ervoir, and the proposed **Site 1** reservoir. These ASR systems are one of the many features described in Components K6, LL6, VV6 and M6, respectively, of Alternative D13R. A recovery efficiency of 70% is assumed for all ASR wells. Injection and retrieval capacities are identical in all ASR locations. All LEC ASRs are proposed to be built in LEC Service Area (LECSA) 1. Their magnitudes are:

ASR designation*	WPBCAT	C51	CPBRES	SITE1
Size, MGD	50	170	75	150

*ASR designation refers to variable name used in SFWMM to identify the ASR.

The other two model runs are scenarios derived from the base run. Scenario 1 was simulated by having ASR injection and withdrawal capacities equal to zero MGD. The configuration and rules governing the operation of the ASRs as simulated in the base run was maintained in scenario 2 -- only the efficiency was changed from 70% to 35%. In the SFWMM, ASR efficiencies are applied upon injection so that the size of the ASR "bubble" at the end of each time step truly represents the available storage in the ASR well.

Assumptions

In both scenario runs, no operational adjustments or physical components were added or substituted to compensate for the reduction in efficiency or elimination of the LEC ASRs. The rest of the components incorporated in Alternative D13R are identical to the ones used in both scenario runs. The modification (elimination or reduction in efficiency) of LEC ASRs were done simultaneously in all locations.

Summary of Results

Performance measure (PM) graphics comparing of selected model output summaries are attached. The base run is designated as **ALTD13R**. Scenario 1 (without ASRs) and scenario 2 (ASRs with 35% efficiency) are designated as **NOLASR** and **35LASR**, respectively, in the attached graphics. Unless, otherwise noted, trends in either scenario run, e.g. increase in discharge or lowering of stages, are expressed relative to the base run. This analysis refers to

ALTD13R as the base run which should be differentiated from the Restudy 1995 and 2050 base runs. Model output corresponding to the 1995 and 2050 base runs are plotted in all PM graphics for reference only. The major findings in this analysis are:

- For Lake Worth Lagoon, the number of high-flow violations significantly increased in the NOLASR scenario relative to the base run (from 96 to 144). For the same estuary, the 35LASR scenario showed a slight increase (from 24 to 27) in the number of low-flow violations compared to the base run (Figure 1).

- Mean annual surface flows to tide did not significantly change for most service areas when ASR efficiencies were lowered from 70% to 35%. However, LECSA 1 exhibited an increase in the mean annual wet season (+32%) and dry season (+28%) flows to tide when the ASRs were completely removed (Figure 2).

- The saltwater intrusion criteria as measured at S-155 (Figure 3) and G-56 were not compromised with or without the proposed LEC ASRs (Figure 4).

- The CPBRES and SITE1 ASRs receive water from their respective reservoirs. The duration curves for Site 1 reservoir does not show a significant difference between the base run and 35LASR scenario (Figure 5). The Central Palm Beach County reservoir dried up approximately 3% of the simulation period more often with a less efficient ASR (Figure 6). The annual/wet season/dry season injection rates, in kaf/yr, for ALTD13R and 35LASR are 55.7 / 39.2 / 16.4 and 55.3 / 38.9 / 16.4, respectively.

- Water restrictions were not affected with or without ASRs in LECSA 1 in terms of number of months of simulated water supply cutbacks (Figure 7). Locally triggered cutbacks in Service Area 1 did not exist even without ASRs.

- Figures 8 and 9 show the average annual regional system water supply deliveries to LEC Service Areas for the entire simulation and the five drought years (1971, 1975, 1981, 1985 and 1989), respectively. The mean annual water supply deliveries, in kaf/yr, by source to Service Area 1 during the five drought years are summarized in the table below. The values in parentheses represent the percent contribution of a given source to the total delivery for each model run.

	Model Run		
Source	ALTD13R	35LASR	NOLASR
LEC ASR	125 (60%)	80 (41%)	0 (0%)
WCA/EAA runoff	53 (26%)	71 (37%)	91 (53%)
LEC Reservoir	20 (10%)	21 (11%)	42 (24%)
Lake Okeechobee	9 (4%)	21 (11%)	40 (23%)
Total	207	193	173

- Reducing the ASR efficiencies from 70% to 35% will: a) reduce the ASR contribution by 36% (from 125 to 80 kaf/yr); b) increase WCA/EAA runoff contribution by 34% (from 53 to 71 kaf/yr); c) approximately maintain the level of contribution from the reservoir; d) increase Lake Okeechobee (LOK) contribution by 133% (from 9 to 21 kaf/yr); and e) decrease the overall supply by 7% (from 207 to 193 kaf/yr). Also, totally eliminating ASRs in LEC Service Area 1 will: a) increase regional delivery (LOK + WCA/EAA runoff) by 111% (from 62 to 131 kaf/yr); b) increase reservoir contribution by 110% (from 20 to 42 kaf/yr); and c) decrease the overall supply by 16% (from 207 to 173 kaf/yr).

- Based on stage duration curves, slight lowering of water levels in WCA-1 can be observed from ALTD13R to 35LASR and from 35LASR to NOLASR for indicator regions 26 and 27 (Figures 10a and 10b). Relative to ALTD13R both scenario runs show that the southern indicator region exhibited greater interannual variation in mean weekly stage compared to the northern indicator region during the first half of the year (Figures 11a and 11b). Inundation duration summaries for indicator regions 26 and 27 in WCA-1 are given below. Both scenario runs show increased number of continuous ponding events, reduced average flooding duration and reduced average annual hydroperiod.

Indicator Region		#Events |	Avg Flood Dur(Wks/Event) |		Avg Ann Hydper(% of year)		
Number	Name	ALTD13R	35LASR	NOLASR	ALTD13R	35LASR	NOLASR
26	South LNWR	7 | 228 |	99	12 | 132 |	98	14 | 112 |	98
27	North LNWR	16 | 96 |	95	19 | 80 |	94	18 | 84 |	94

notes: #Events = number of continuous ponding events over the period of record
Average Flood Duration = [sum(days of ponding)/7]/#Events
Average Annual Hydroperiod = 100 x [sum(weeks of ponding per year)]/[52 x #years]

- The mean annual EAA/LOSA supplemental irrigation for both the entire simulation (Figure 12a) and the five drought years (1971, 1975, 1981, 1985 and 1989; Figure 12b) did not change significantly.

- Both scenarios marginally lowered stages in Lake Okeechobee (Figure 13). The NOLASR scenario showed an increase in both the percent (from 9 to 11%) and the number of times (from 10 to 13) low stage (12 ft NGVD) criteria exceedance. Likewise, the 35LASR scenario showed an increase in the percent (from 9 to 10%) but no change in the number of times (10) low stage criteria exceedance (Figure 14).

Fig. 1 Number of Times Salinity Envelope Criteria were NOT met for the Lake Worth Lagoon (mean monthly flows 1965 − 1995)

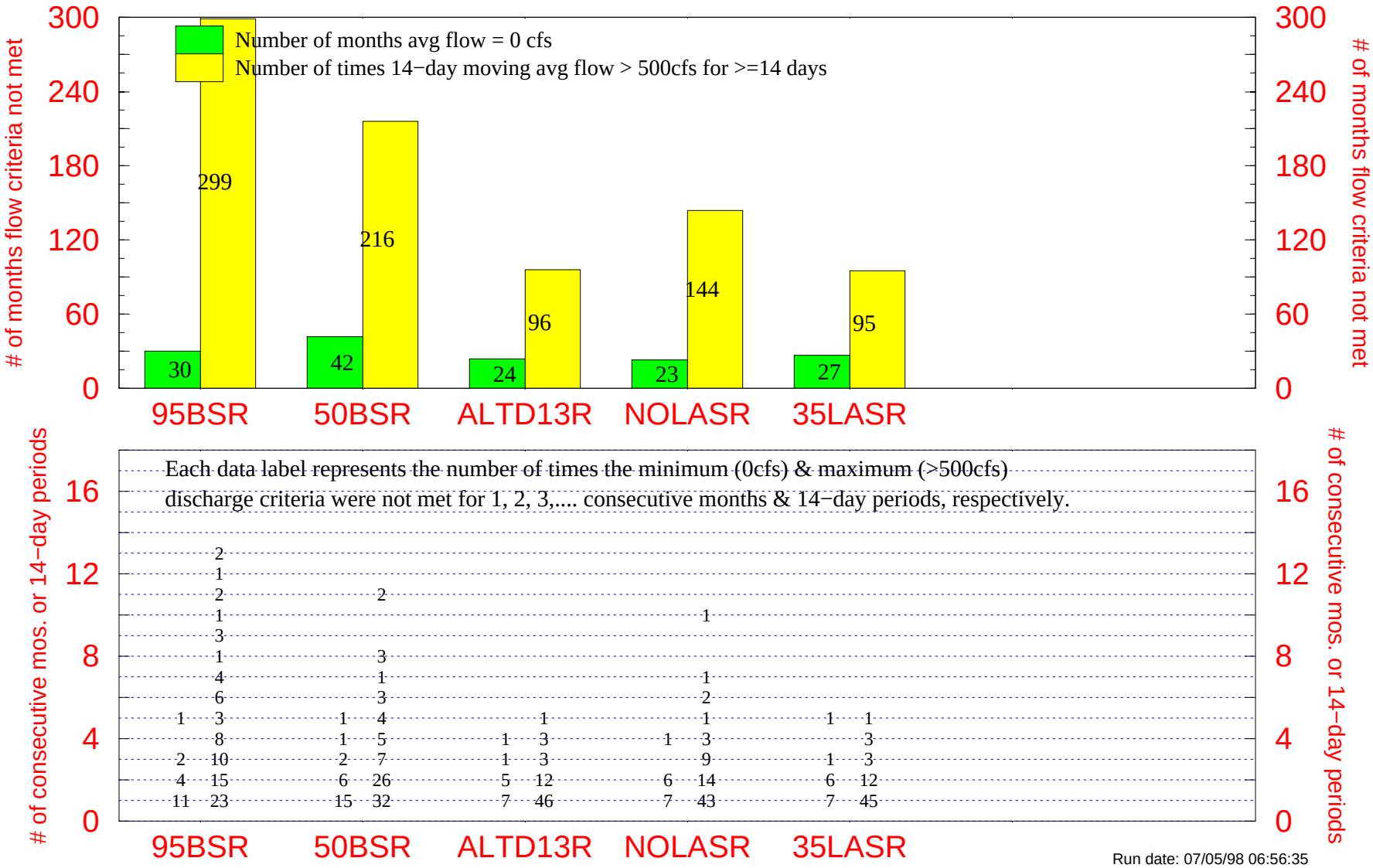

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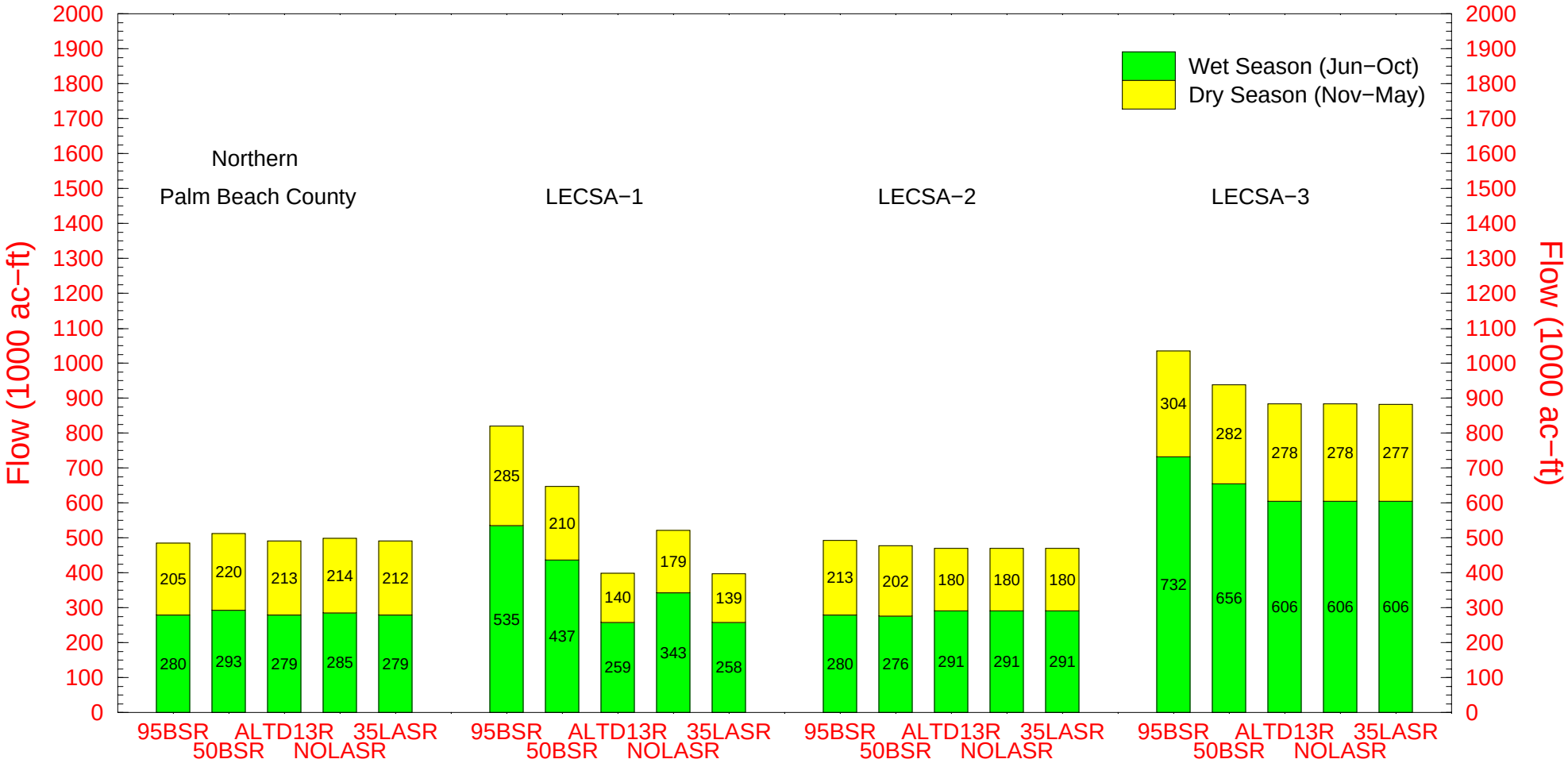
Fig. 2 Mean Annual Surface Flows Discharged to Tide from the LECSA for the 1965 − 1995 Simulation Period



Service Area Canals Discharging to Tide:

Northern PB Co. = C−17
LECSA−1 = C−51, C−16, C−15 and the Hillsboro Canal
LECSA−2 = C−14, C−13, C−12, North New River Canal and C−10
LECSA−3 = C−9, Miami Canal, C−8, C−7, Coral Gables Canal, C−2,C−100A, C−100B, C−1, C−102, C−103, Military Canal and Model Land Canal

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Fig. 3 Percent of Time Canal Stage < Salt−Water Intrusion Criteria & Occurences > 1 Week
Canal C−51 at S−155 (Salt−Water Intrusion Indicator Stg = 7.75 ft, NGVD)

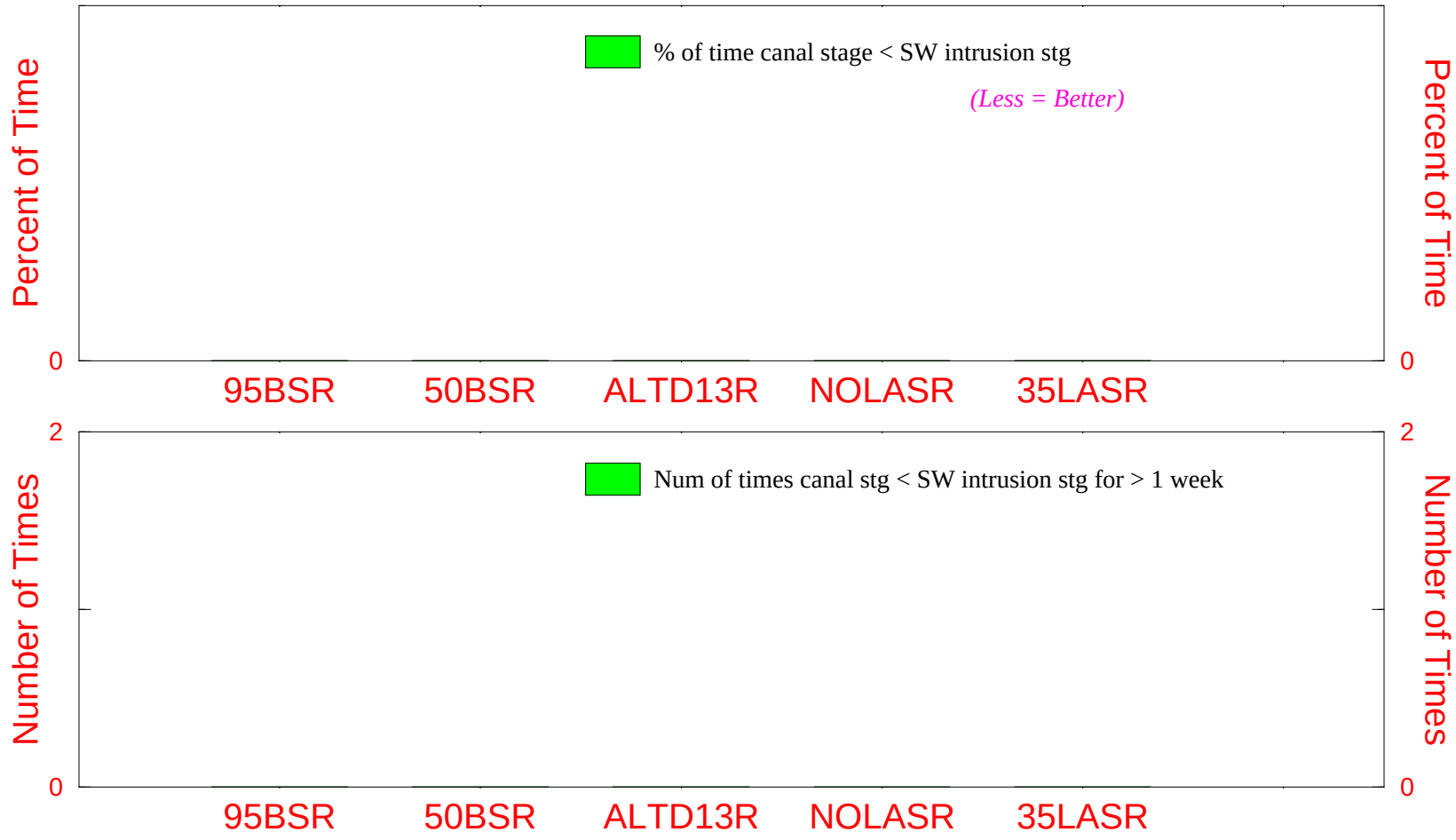

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Fig. 4 Percent of Time Canal Stage < Salt−Water Intrusion Criteria & Occurences > 1 Week
Canal Hillsboro at G−56 (Salt−Water Intrusion Indicator Stg = 6.75 ft, NGVD)

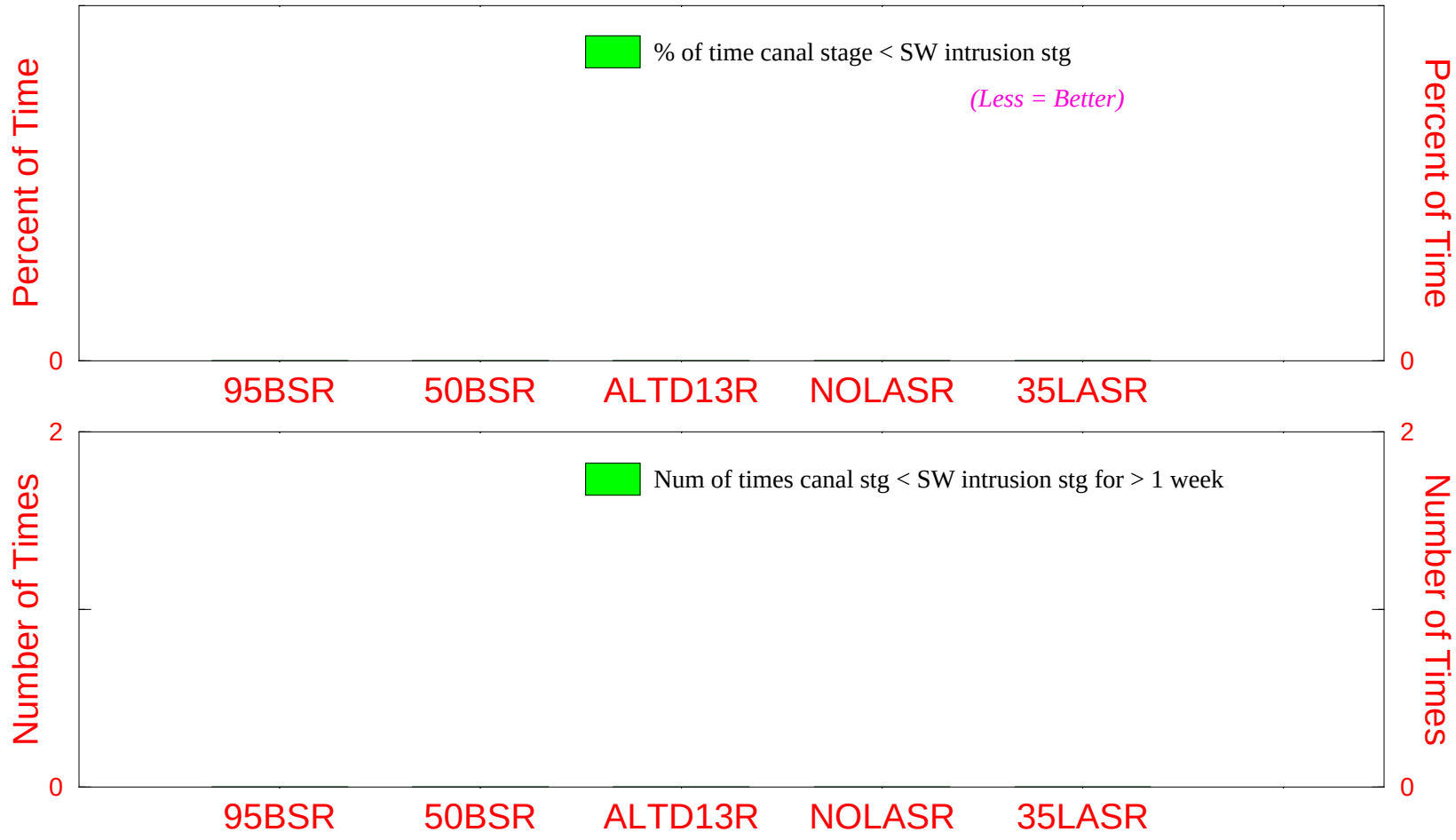

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Fig. 5 Stage Duration Curves at Site 1 Reservoir

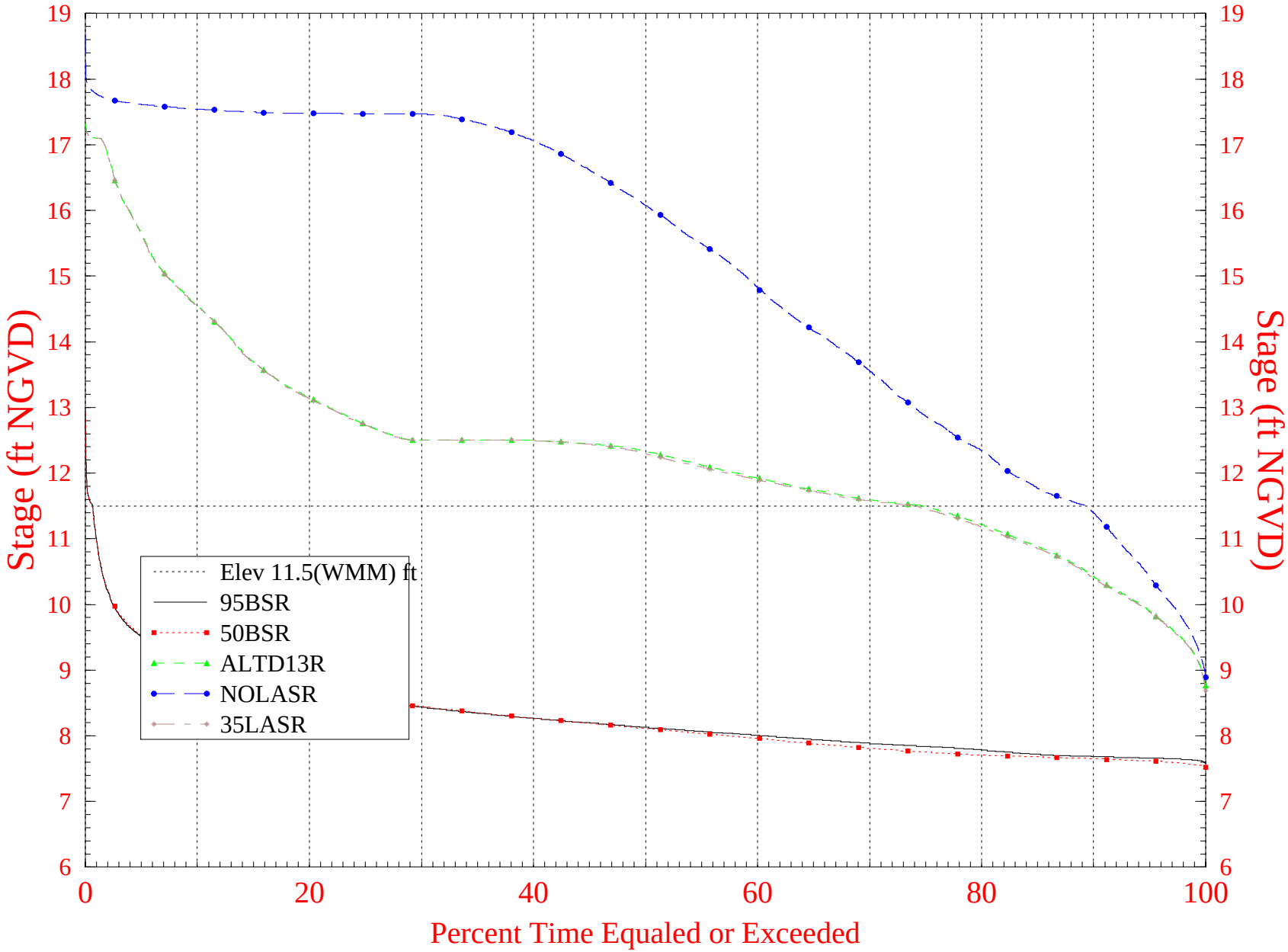

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Fig. 6 Stage Duration Curves at Central PBC Reservoir

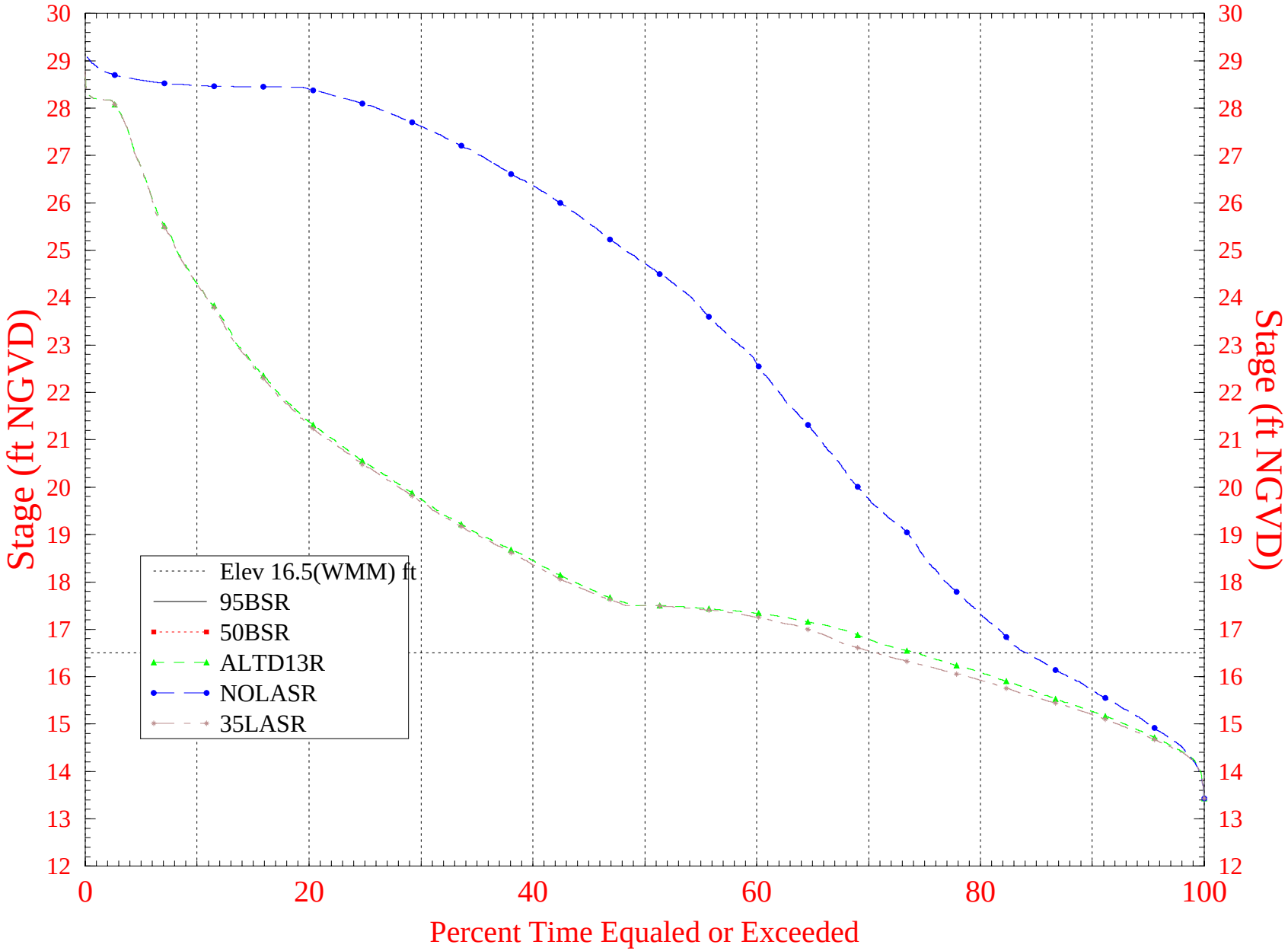

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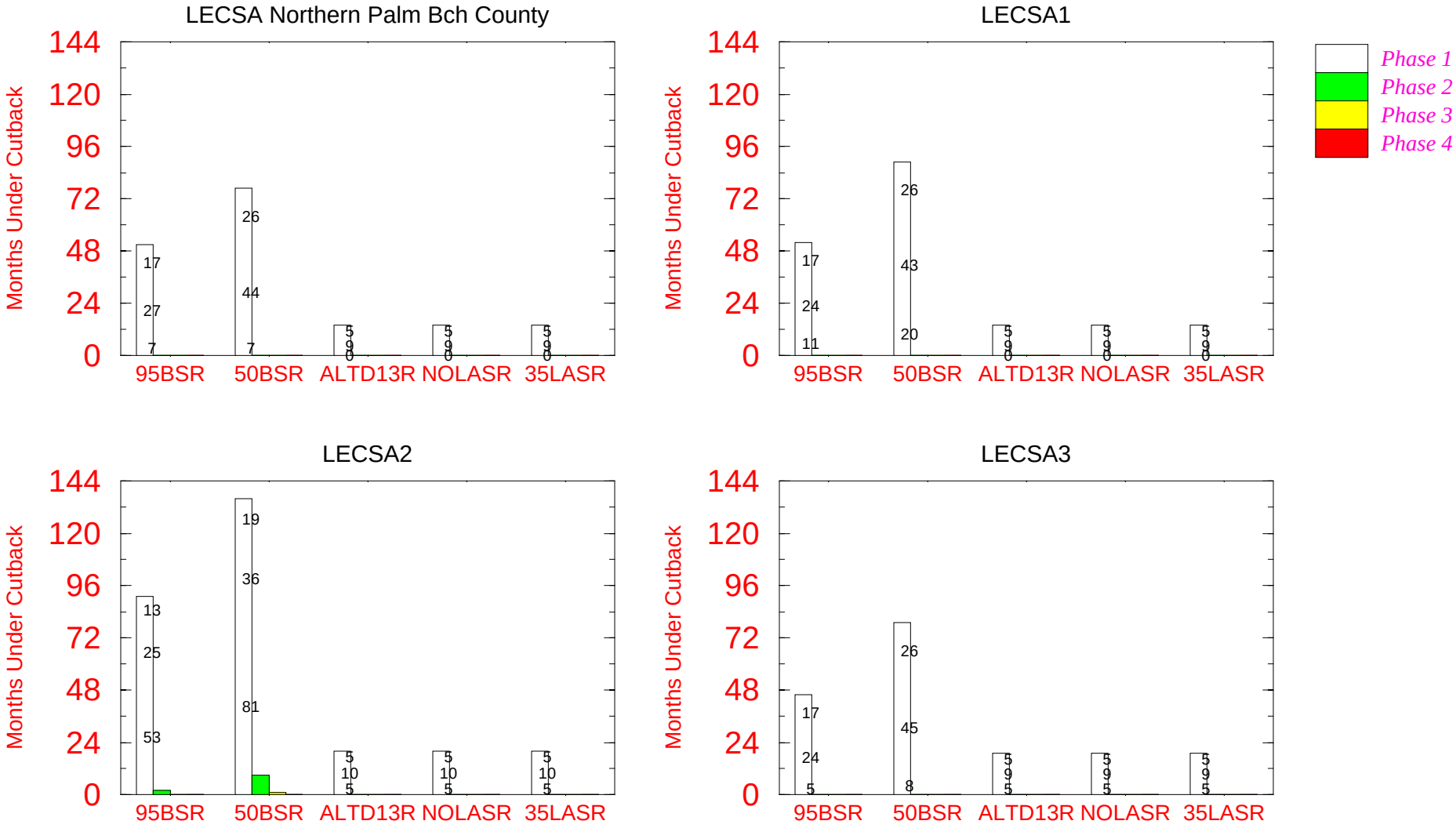
Fig. 7 Number of Months of Simulated Water Supply Cutbacks for the 1965 – 1995 Simulation Period



Note: Phase 1 water restrictions could be induced by a) Lake stage in Supply Side Management Zone (indicated by upper data label), b) Local Trigger well stages (lower data label), and c) Dry season criteria (indicated by middle data label).

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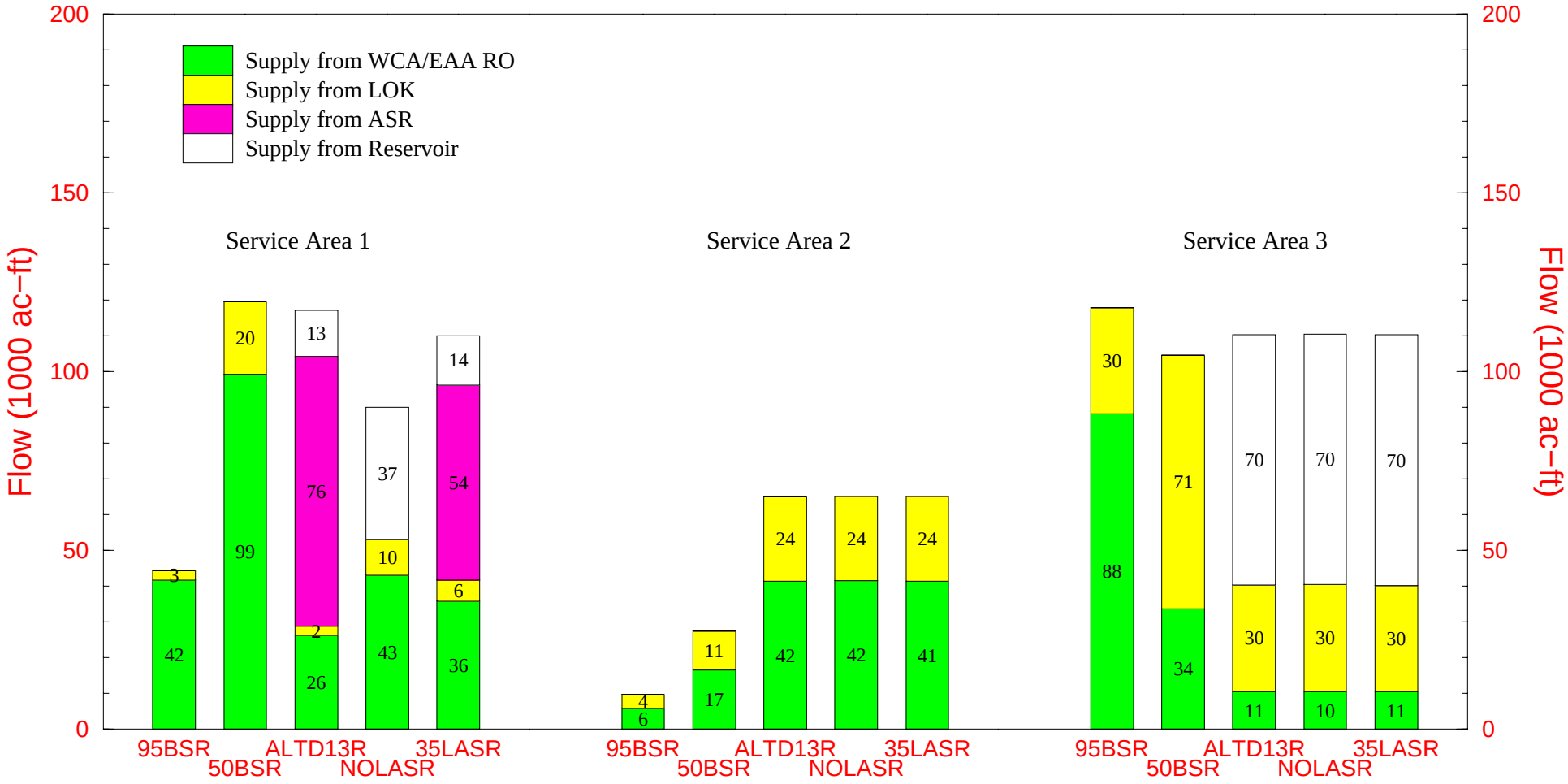
Fig. 8 Average Annual Regional System Water Supply Deliveries to LEC Service Areas for the 1965 – 1995 simulation



Note: Structure flows included: SA1=S39+LWDD+ADDSLW+ACMEWS+WSL8S+HLFASR+C51FAS+WSC1+S1ATHL+CPBRWS+BPRL8S
SA2=S38+S34+NNRFAS; SA3=S31+S334+S337+BRDRWS+LBTC6+LBTDBL+LBTL30+LBTSC+LBTC9+LBTC2+C9RWS
Supply RECEIVED from LOK may be less than what is DELIVERED at LOK due to conveyance constraints.
Regional System is comprised of LOK and WCAs.

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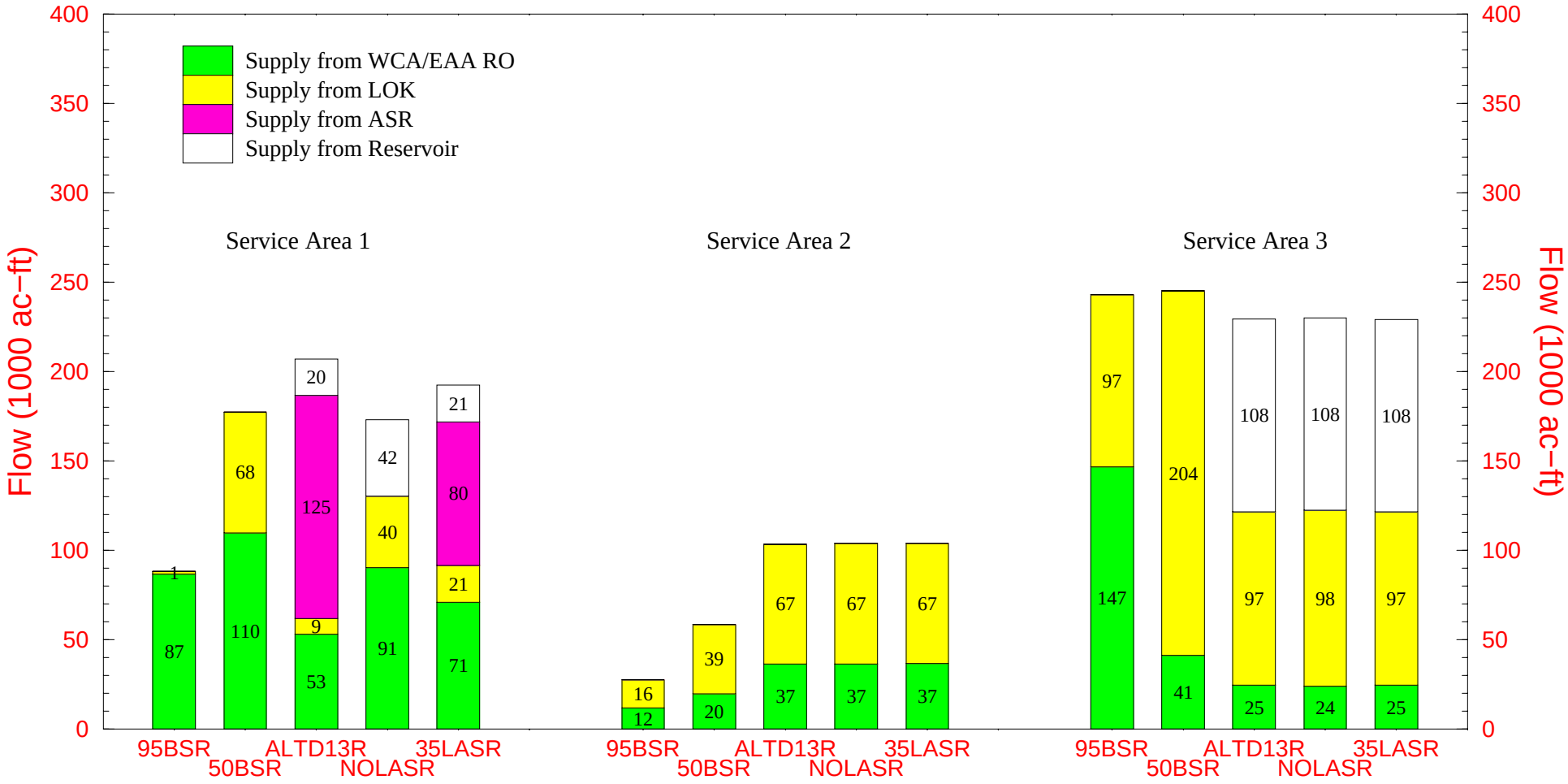
Fig. 9 Mean Annual Regional System Water Supply Deliveries to LEC Service Areas for the five Drought years (71,75,81,85,89)



Note: Structure flows included: SA1=S39+LWDD+ADDSLW+ACMEWS+WSL8S+HLFASR+C51FAS+WSC1+S1ATHL+CPBRWS+BPRL8S
SA2=S38+S34+NNRFAS; SA3=S31+S334+S337+BRDRWS+LBTC6+LBTDBL+LBTL30+LBTSC+LBTC9+LBTC2+C9RWS
Supply RECEIVED from LOK may be less than what is DELIVERED at LOK due to conveyance constraints.
Regional System is comprised of LOK and WCAs.

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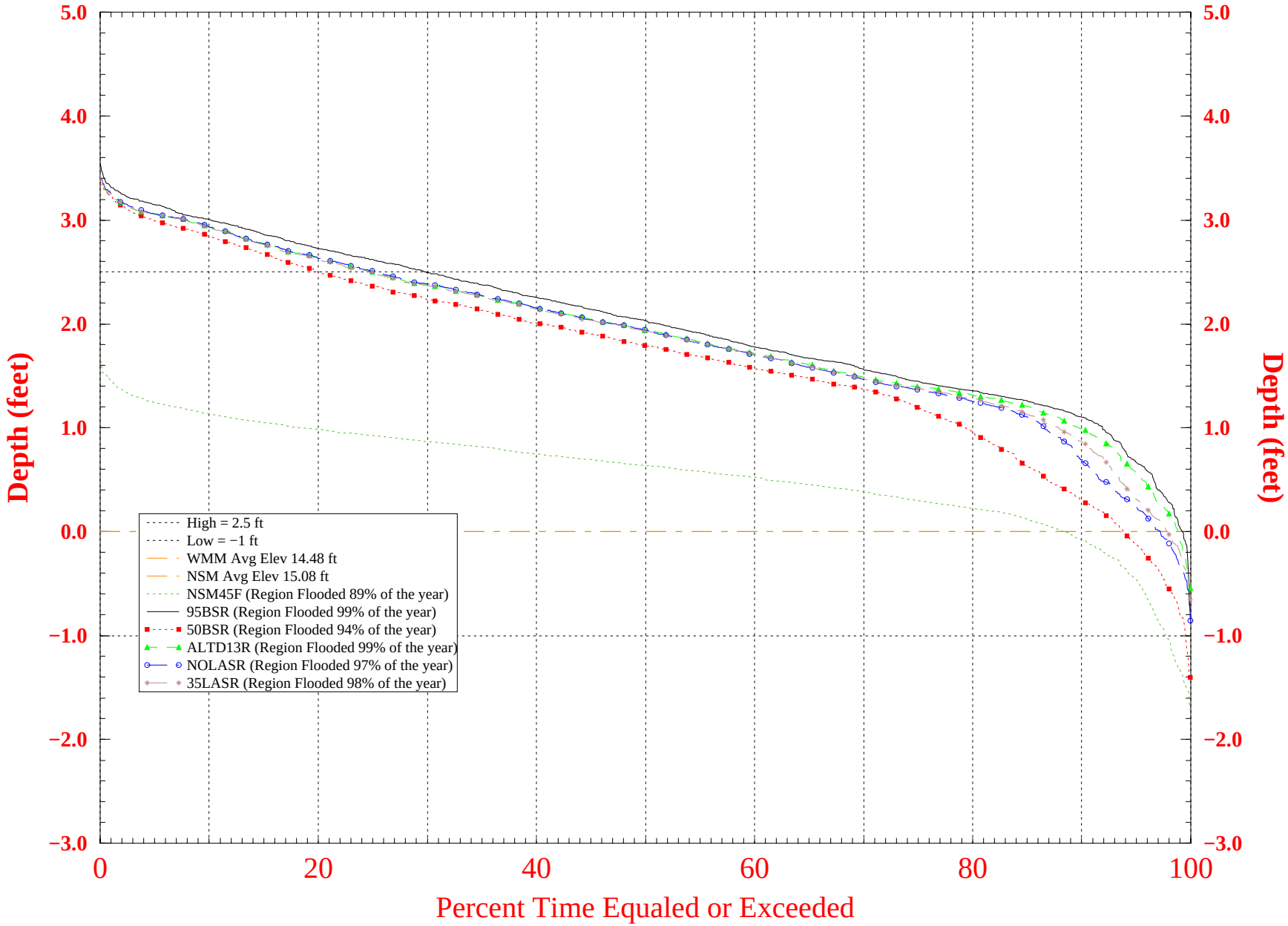
Fig. 10a Normalized Weekly Stage Duration Curves for South LNWR (WCA−1)

Indicator Region 26 (R44C31−34 R45C30−34)



Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding while values below zero indicate depth to the water table.

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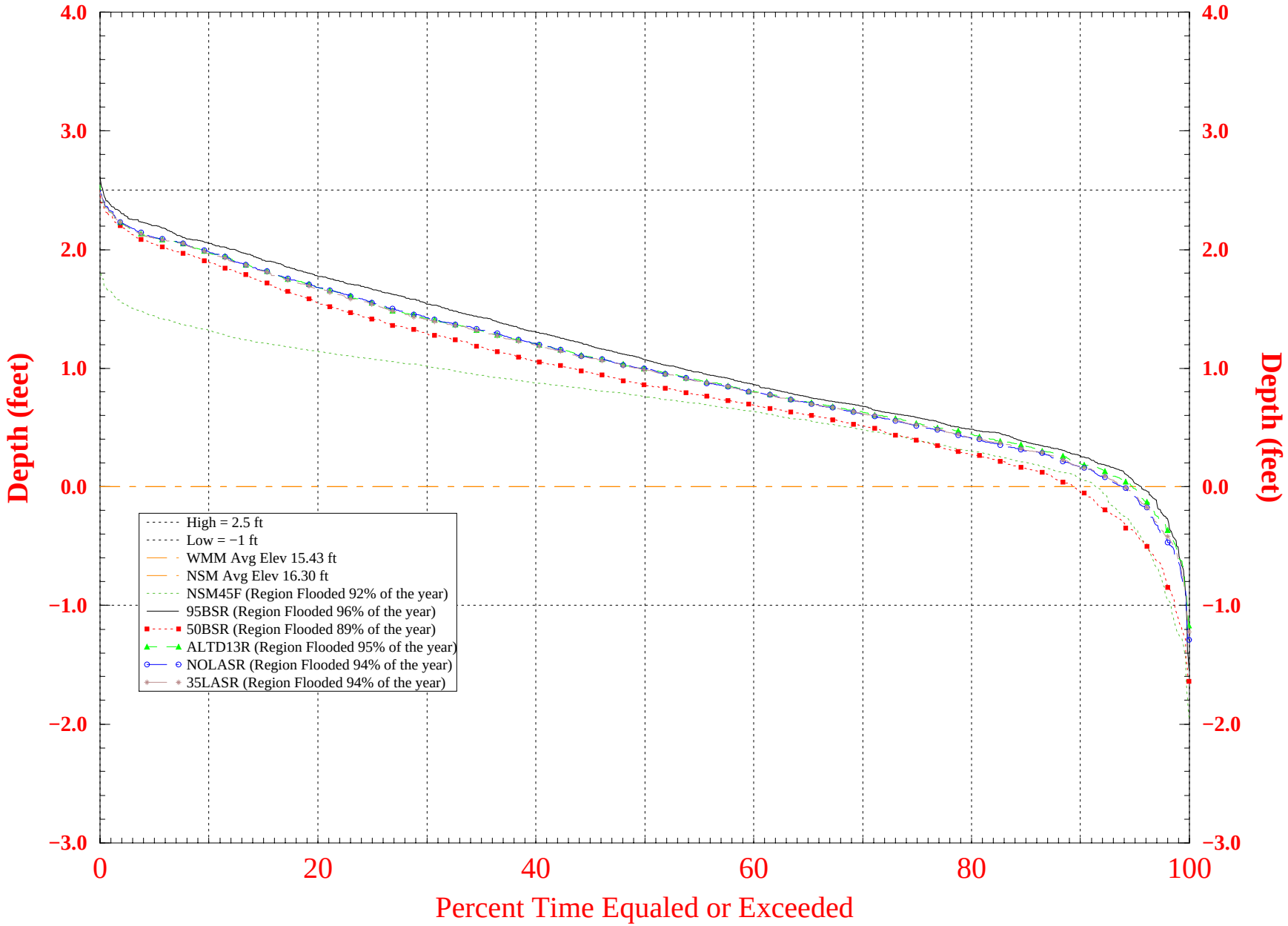
Fig. 10b Normalized Weekly Stage Duration Curves for North LNWR (WCA−1)

Indicator Region 27 (R47C30−34 R48C30−33 R49C30−33 R50C30−32 R51C30−31)



Note: Normalized stage is stage referenced to Land Elevation. Thus, values above zero indicate ponding while values below zero indicate depth to the water table.

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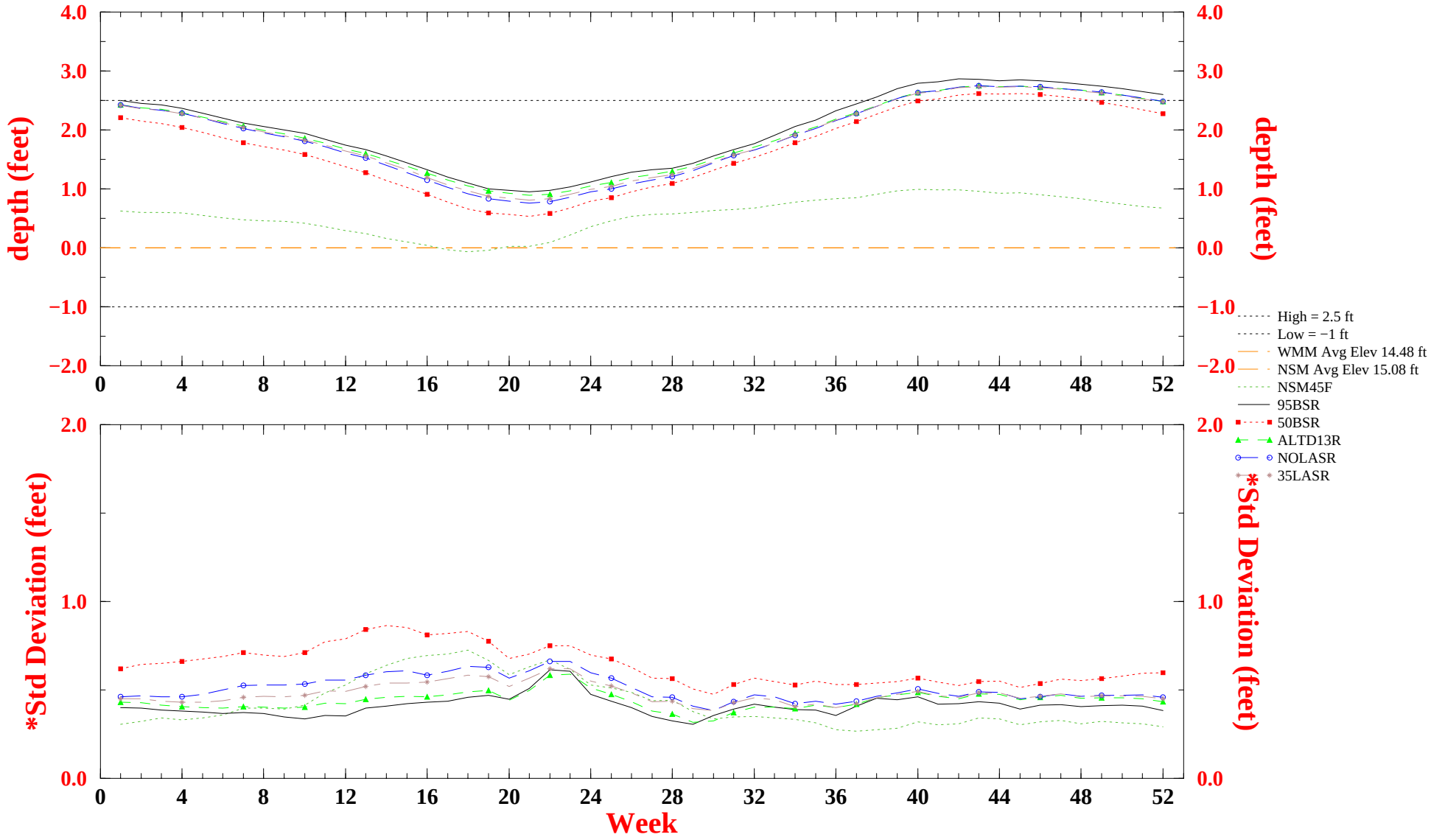
Fig. 11a Temporal Variation in Mean Weekly Stage for South LNWR (WCA−1)

Indicator Region 26 (R44C31−34 R45C30−34)



WEEK 1 STARTS JAN 1

Depth and elev are weekly means for the indicator region for a 31 year simulation

High/Low = 0 indicates criteria undefined for region

* Standard Deviations are calculated among−year values;
* they illustrate interannual variation in mean weekly depth over the 31 year simulation period.

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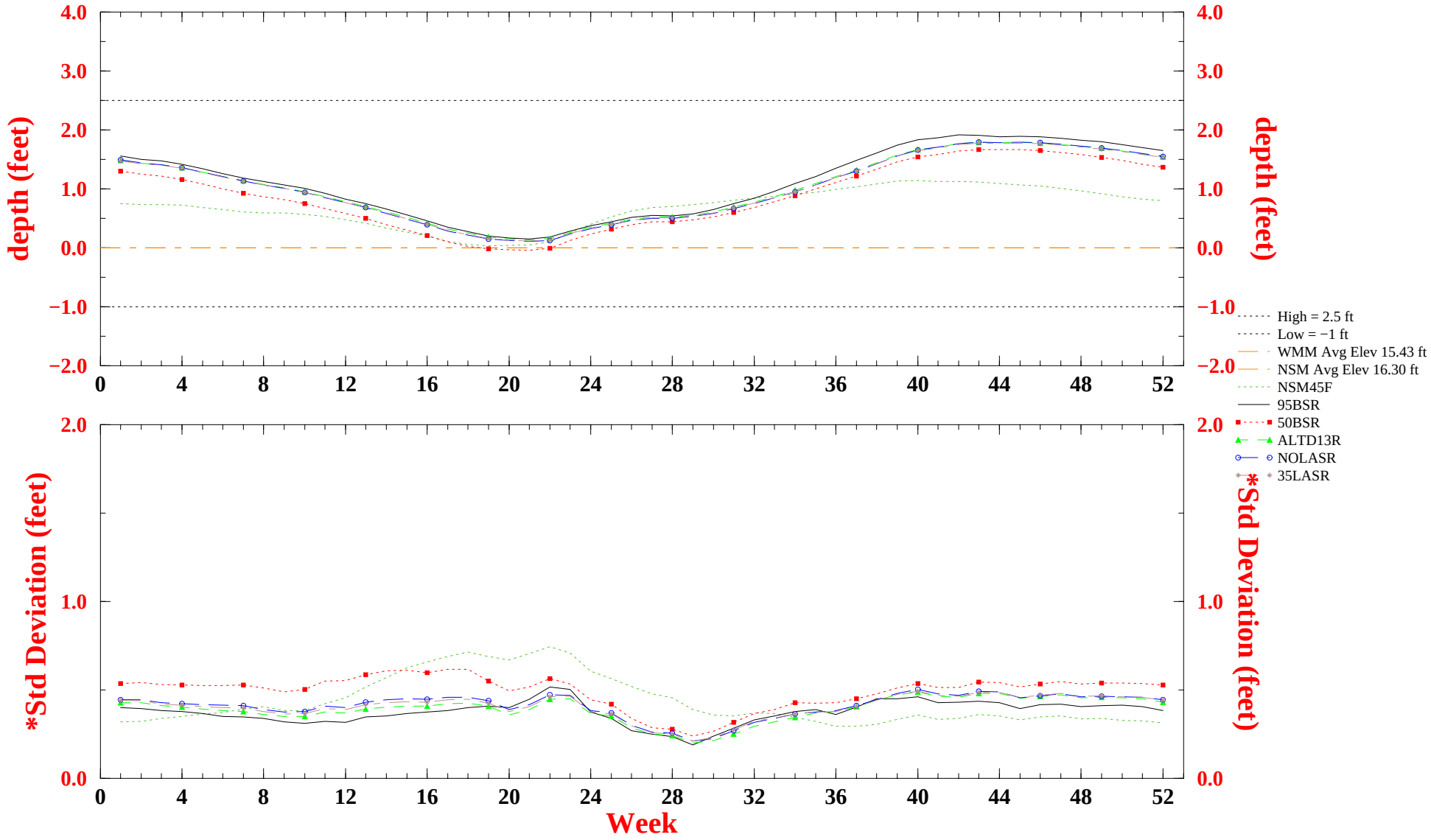
Fig. 11b Temporal Variation in Mean Weekly Stage for North LNWR (WCA−1)

Indicator Region 27 (R47C30−34 R48C30−33 R49C30−33 R50C30−32 R51C30−31)



WEEK 1 STARTS JAN 1

Depth and elev are weekly means for the indicator region for a 31 year simulation

High/Low = 0 indicates criteria undefined for region

* Standard Deviations are calculated among−year values;
* they illustrate interannual variation in mean weekly depth over the 31 year simulation period.

Run date: Sun Jul 5 10:49:33 EDT 1998

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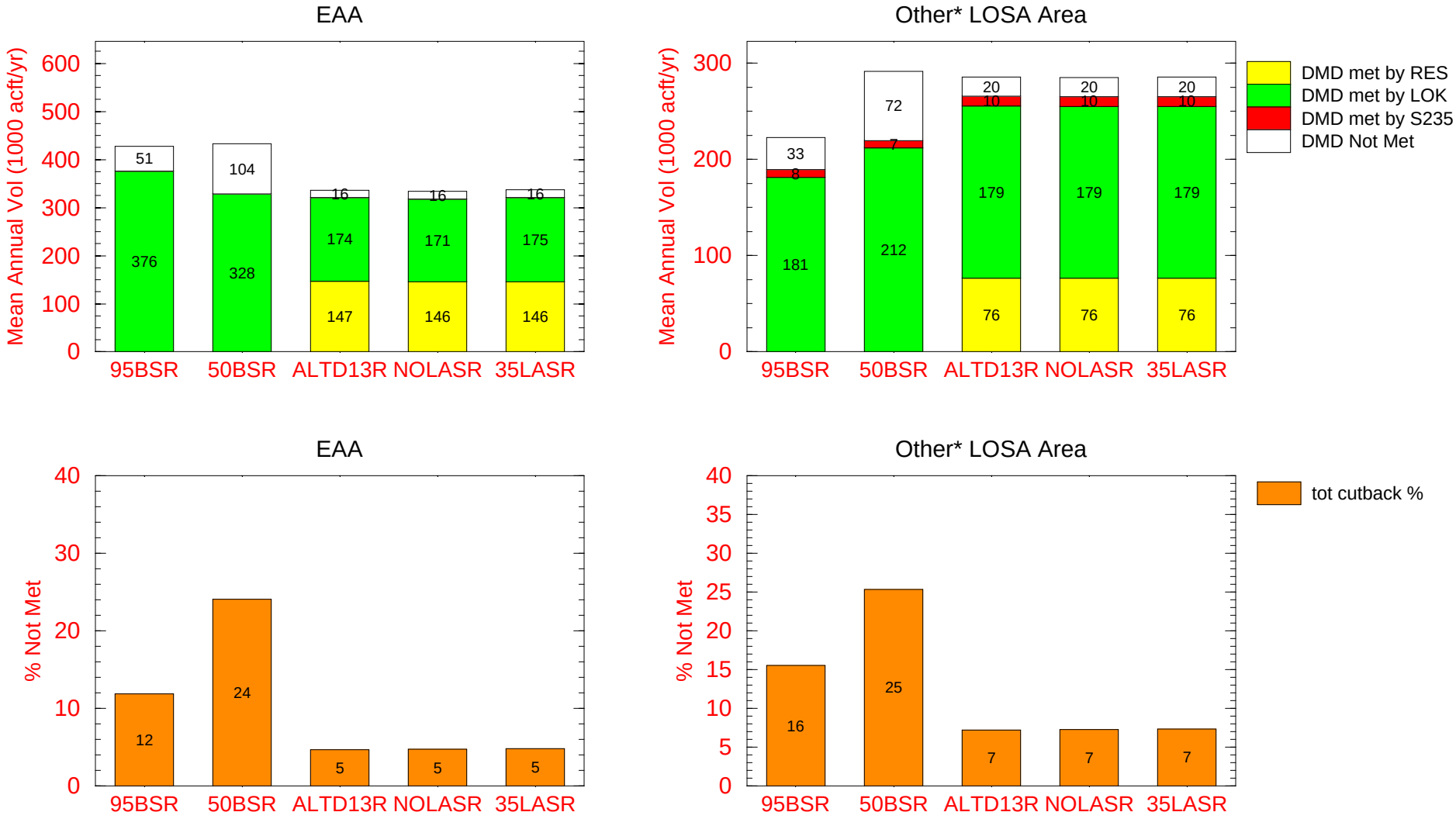
Fig. 12a Mean Annual EAA/LOSA Supplemental Irrigation: Demands and Demands Not Met

for the 1965 − 1995 Simulation Period



*Other Lake Service SubAreas (S236, S4, L8, C43, C44, and Seminole Indians (Brighton & Big Cypress)).

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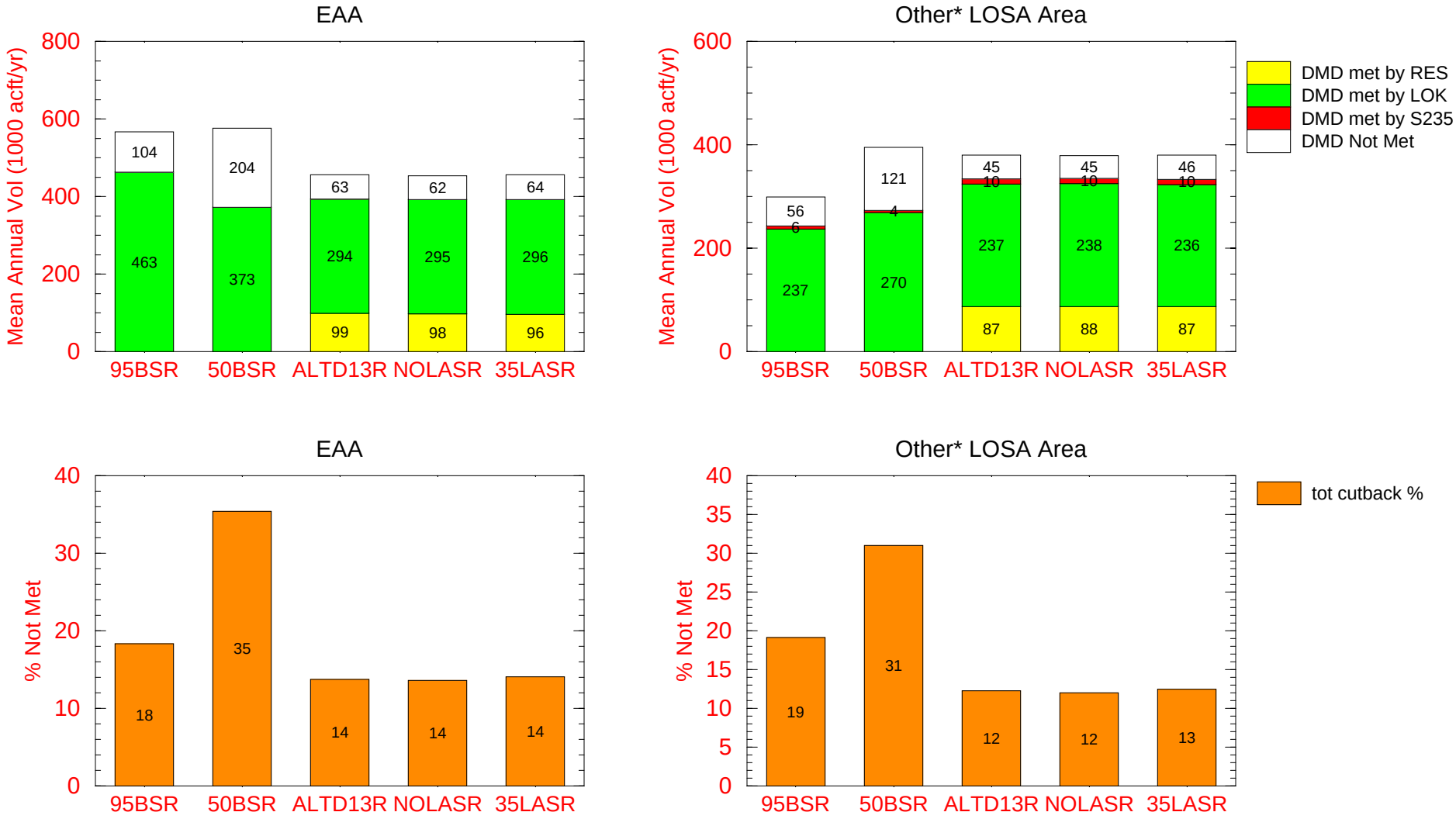
Fig. 12b Mean Annual EAA/LOSA Supplemental Irrigation:

Demands and Demands Not Met for the Drought Years:

1971, 1975, 1981, 1985, 1989 within the 1965 − 1995 Simulation Period



*Other Lake Service SubAreas (S236, S4, L8, C43, C44, and Seminole Indians (Brighton & Big Cypress)).

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Fig. 13 Lake Okeechobee Stage Duration Curves

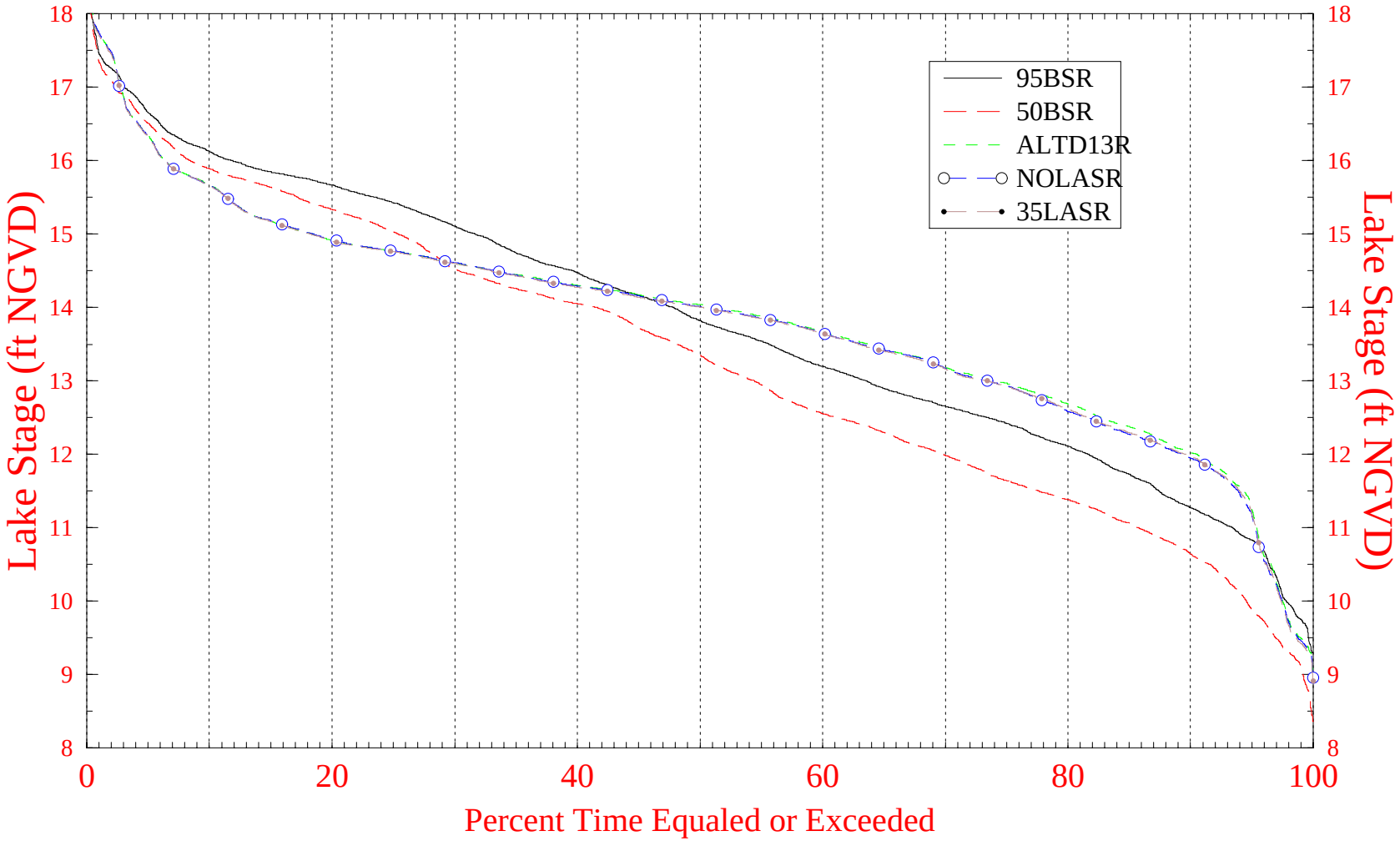

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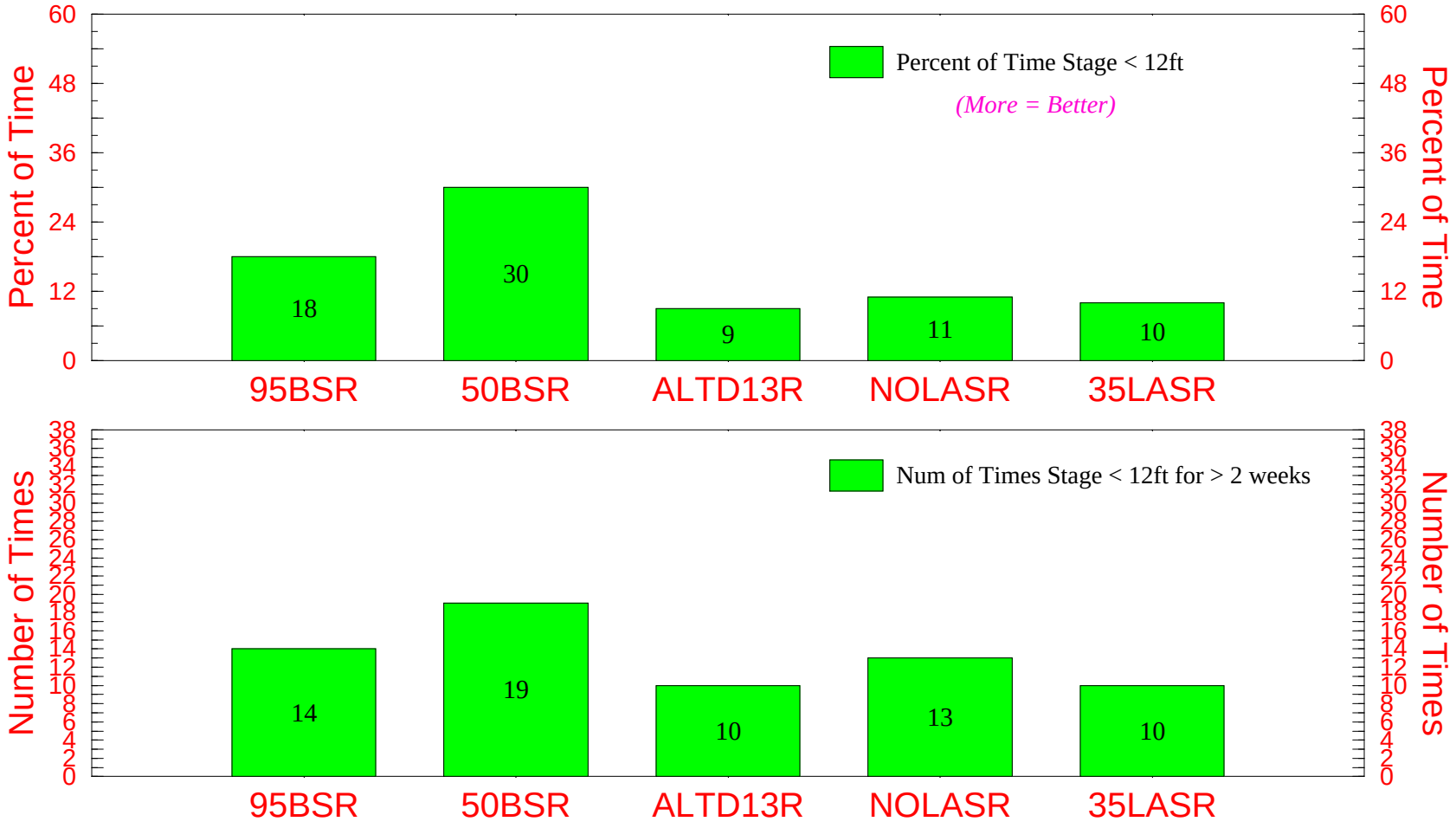
Fig. 14 Percent of Time Lake Stage < 12ft NGVD and Number of Times Lake Stage < 12ft NGVD for > 2 weeks



* Short−term drying of the marsh allows for seed germination of beneficial plants, improves wading bird and snail kite habitat (eg. regrowth of willow) and helps to maintain the natural diversity and abundance of littoral zone biological communities.

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